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GEOPHYSICS.—*Note on temperature gradients in the Permian basin.*[1] WALTER B. LANG, U. S. Geological Survey. (Communicated by W. C. MENDENHALL.)

It has been shown[2] that the isogeothermal surfaces in the Permian Basin of West Texas and southeastern New Mexico are depressed and that this subnormal condition appears to have some relationship to the distribution and thickness of the halite and anhydrite deposits. In the fall of 1929 an opportunity was afforded to make a temperature test in a well which was so located as to yield some evidence as to the factor or factors of a large group of variables which might be responsible for the effect. This well (Transcontinental-McWhorter No. 1, Sec. 6, T. 3 S., R. 22 E., De Baca County, N. Mex.) was drilled through rocks locally identified as the lower San Andres, Yeso, Abo (Permian), and Magdalena (Pennsylvanian) formations and into what are believed to be representatives of the pre-Cambrian schists and quartzites which outcrop in the Hills of Pedernal some 60 miles to the northwest. The San Andres and Yeso formations of this area are of interest because they are composed of limestone and anhydrite and therefore contain only one of those two prominent but characteristic sediments, halite and anhydrite, of the Permian Basin. This well by reason of its marginal position also has a stratigraphic range far greater than even deep wells in the basin proper. The geothermal gradient curve of this well began as representative of the region but on approaching the Abo formation began to take on a noticeably accelerated increase, so that on reaching a depth of 4,400 feet a temperature that would be high for the Permian Basin was recorded. It appears therefore that in-

[1] Published by permission of the Director of the U. S. Geological Survey. Received February 18, 1930.

[2] This JOURNAL 19: 232. 1929.

ternal heat is being dissipated more rapidly by the upper anhydrite-bearing sediments of this section than it is being supplied by the lower.

If the thermal conductivity tables for rocks are consulted it is found that the majority of the more usual types have conductivities within the range of .002 to .008 calories (cm. sec. Grad.). Anhydrite and halite are reported to have conductivities of .0123 and .0137 calories, respectively. Now it is indicated by this test that anhydrite alone, present as alternate beds with limestone in the upper section of the well, influences the character of the gradient curve by depressing it. The previously noted apparent westward extension of subnormal temperatures beyond the halite boundary is thus also subject to explanation. Also the diathermanous property of halite is eliminated as a primary factor, for if this property of halite were the sole cause of subnormal temperatures in the basin the effect could not be recorded in this well. Anhydrite in association with even thicker beds of halite of still greater conductivity coefficient in the basin proper may be expected to conduct heat faster than it can be supplied by other sediments at greater depth. It is therefore reasonable to suppose that the depression of the isogeotherms of the Permian Basin are the direct result of the high thermal conductivities of these two prominent sediments.

Other sedimentary regions involving considerable halite or anhydrite not covered by too great an overburden of low conductivity rocks should yield low gradients, if the area in which they occur is not subject to other extraneous heat-producing sources. The Permian saline deposits of Germany have been so affected by tectonic disturbances as apparently to have counteracted the expectable high conductivity influences.

Radioactivity is proposed by some authorities as one of the principal sources of the earth's heat. Potassium is radioactive (Beta-ray) and even though the unit energy is low in proportion to uranium, the percentage of potassium present in the average rock is sufficient to produce heat equivalent to that of uranium.[3] The saline deposits (late Paleozoic) of West Texas and New Mexico for an area of more than 40,000 square miles carry potash in disseminated and concentrated form. Local areas equivalent in size to a township have beds 6 to 15 feet thick analyzing 10 to 30 per cent of potash (K_2O). These deposits have remained undisturbed during all of Mesozoic and Ceno-

[3] ARTHUR HOLMES and R. W. LAWSON, *Potassium and the heat of the earth.* Nature, May 1, 1926, pp. 620-621.

zoic time, yet in only one temperature test made in a well penetrating these beds is there the faintest suggestion of the possible influence of radioactivity and even in this case the variation may be explained on another basis. Despite this radiothermal heat the temperature gradients are excessively low. More powerful agencies than radioactivity control geothermal gradients in the basin. Perhaps radioactivity is also of minor importance in other areas of the earth.

A sphere of uniform composition heated at the center and cooling at the surface has perfect concentric isothermal zones. Wanting evidence to the contrary, it is assumed the inner portion of the earth is isothermally zoned. The crustal portion of the earth, variable in composition and relief, must have isothermal surfaces broadly expressing the influences of these variations.

An explanation of the varying behavior of the isogeotherms of any region is very likely to be dependent, in part or in whole, upon differential rock conductivities. Critical data of the sort necessary to determine the influence of rock conductivities in general upon temperature gradients do not exist. This is largely due to the fact that such determinations as have been made (industrial, building stones, etc.) were not made with a view to the solution of geological problems. Compaction, porosity, bedding, mineral orientation, degree of crystallization or cementation, water content, etc., are in only a few instances considered or noted. Nevertheless, these small factors sometimes yield enormous cumulative effects. Questions of conductivity parallel and perpendicular to bedding can not be decided by data now at hand. A dry sediment compacted by loading may have greater density across the bedding and therefore greater conductivity in this direction. However, the same rock saturated with water[4] may have greater conductivity along the bedding. Whether or not oil-bearing anticlines owe their heat to exothermic reactions or stratified thermal conductivity is a question dependent upon more specific data. Mass orientation of minerals of ellipsoidal conductivity properties may be expected to give widely divergent results for different positions of the rock specimens.

Until supposition is supported by more exact basic criteria reasoning about geothermal problems is apt to rest on an unsound foundation. There is urgent need for data on the thermal conductivity of rocks as they exist under natural conditions.

[4] JOSEPH PRESTWICH, *Controverted questions in geology*. Macmillan & Co., 1895, p. 241.

PHYSICAL GEOGRAPHY.—*Peat profile studies in Maine: The South Lubec "heath" in relation to sea level.*[1] A. P. DACHNOWSKI-STOKES, U. S. Bureau of Chemistry and Soils.

I

The following study, carried out principally south of Lubec at Carryingplace Cove in Maine, was made with two purposes in view. In connection wth field work regarding the quality and possible uses of moss peat in "heaths," it contemplated an intensive profile study of an exposed coastal highmoor which is being cut back by waves at a rapid rate. At the same time it was hoped that observations of sufficient precision concerning the position of the moor in relation to sea level would furnish the necessary data for determining, by comparison with later observations, whether or not the coast was subsiding.

Carryingplace Cove occupies the eastern extremity of Maine in Grand Manan Channel and lies close to the boundary line of New Brunswick, Canada. The general position and surrounding environment of its peat area are illustrated on chart No. 801 of the U. S. Coast and Geodetic Survey and on the maps accompanying the Eastport Folio No. 192 of the Geologic Atlas of the United States.

The topography of the deeply embayed coast has been recognized as giving evidence of normal drowned valleys and of indicating that the thin southern edge of the last continental ice sheet had not greatly altered the character of the valleys. At the time of the retreat of the ice the Eastport region is believed to have been at least 100 feet lower with reference to sea level than at present. This is indicated by numerous small deposits of marine gravel beds with delta structure fronting the ocean. Glacio-marine sands and clays were laid down in the extended sea of that period and eroded more or less as the ice retreated and the land rose to its present height.

The geology and botany of the region and adjacent portions of New Brunswick, Canada, have been investigated by American and Canadian scientists and from a summary of these studies, notably the work of Ganong (16, 17) Fernald (14), Bastin (3, 4) Johnson (18), and others, it is apparent that the general features have already been correctly interpreted. Accumulating evidence indicates, however, that certain

[1] Received February 15, 1930. The field work was done in September 1929 with the assistance of R. D. KNIGHT. The map, photograph, and control data of elevations above sea level are contributed by R. J. BELTON of the U. S. Geological Survey, to whom the writer desires to express his obligation and appreciation of the interest and aid rendered in furthering the work.

salient details have not been worked out. One of the most interesting questions to be considered concerns, on the one hand, the nature of the different layers of peat and the climatic conditions under which they were formed during the past period; on the other hand, the variations in sea level that may have taken place since that time, either a sinking of the coast to the northwest or a rise in sea level.

Postglacial deposits which began to form in late Pleistocene and have continued to the present day include areas of peat. Many of the beaches as well as peat deposits along the coast are fully exposed to the wave action of the Atlantic, and erosion is dominant at present. Bastin (4) reports on the shore of Moose Island due south of Carlow Island an area of peat which is now flooded by the sea at high tide and is thus being converted into a salt marsh. Bartlett (2) described a peat deposit on the shore of Quamanisset Harbor near Woods Hole, encroached upon by salt marsh. Dawson (13), Chalmers (5) and others have pointed out locations of submerged forests in Canada and Johnson (18) and Daly (12) have assembled much evidence to show that such changes are in progress elsewhere.

Significant in connection with this discussion are recent peat profile studies made on an eutropic lowmoor of the semi-arid region—the Delta Land in California (11). The area is a bay-like depression near the outlet of the Sacramento and San Joaquin Rivers and is located at sea level. In vertical structure the deposit represents essentially the successional stages of vegetation leading from open water to marsh, that is to say, it presents the aspects of a two-layered, limnogenic profile series characterized by a basal layer of finely divided sedimentary peat, derived from submerged and semi-aquatic, fresh-water plants, followed by a surface layer of fibrous peat originating from reeds (*Phragmites* sp.) and tule (*Scirpus* sp.). The shore line of the ancient lake is at present over 20 feet below sea level, from which it appears that a general downward movement has been in progress near San Francisco Bay. Such subsidence is indicated, moreover, by two feet of silty salt marsh overlying reed and tule peat near Fairfield in Suisun Bay, California. The Delta region is particularly interesting both because it is regarded as the best case of drainage in connection with irrigation, navigation, and flood control, and because of the fact that subsidence seems inevitable on account of the well-established oscillations along the Pacific Coast.

In striking contrast is the profile structure of an eutrophic lowmoor of the sub-tropical region, notably that portion of the Florida Everglades bordering the southern shore of Lake Okeechobee (10). A basal

layer of fibrous sawgrass (*Cladium* sp.) peat is succeeded by a surface layer of relatively dense, impermeable sedimentary peat, characterizing a two-layered, telmatogenic profile series. Lake Okeechobee is a body of water in a hydrostatic condition; it was impounded relatively recently to a height of more than 20 feet above sea level by the accumulation of the superimposed layer of sedimentary material and buoyancy of fibrous peat layers retarding the movement of inundating floodwaters. The profile records obtained in the Everglades lead toward the conclusion that the area began as an autochthonous deposit with sedge peat accumulating over bedrock on an essentially stable shore line of the Atlantic Coast. It will be worth while therefore, to ascertain whether peat deposts on the sea coast in northeastern Maine offer convincing facts which may amplify or clarify those furnished by other investigators, and to test as well the theory, offered by geologists, and physiographers, of a general submergence of the North Atlantic Coast.

II

The South Lubec "heath" at Carryingplace Cove, shown in fig. 1, occupies nearly all the neck of land connecting West Quoddy Head with the mainland. The deposit covers today only 20 to 25 acres and is protected on the south by a broad sandy barrier beach. On the north it is entirely unprotected from the action of ocean waves and exposed as a nearly vertical cliff, about 10 feet high, from which every storm causes the removal of masses of peat. According to residents over one-fourth of the present acreage has been swept away by the force of the waves during the last 25 years.

The peat area is of peculiar interest on account of the unusual assemblage of plants, native to both Europe and America, and the raised, dome-shaped configuration of its surface, rising 6 to 8 feet from margin to center (7, 20). The present vegetation is predominantly of northern range, with a number of arctic plants. A conspicuous example is the crowberry, *Empetrum nigrum*, which is abundant on the peat deposits along the Bay of Fundy but elsewhere and inland occurs only above timber line, as at Mt. Washington in New Hampshire, or Mt. Rainier in the State of Washington.

There is a marked similarity in vegetation between the different convex-shaped "highmoors" which extend in a widening belt from the northeastern coast of Maine into New Brunswick, Canada (16). An abundant development of sphagnum mosses grows in rounded hum-

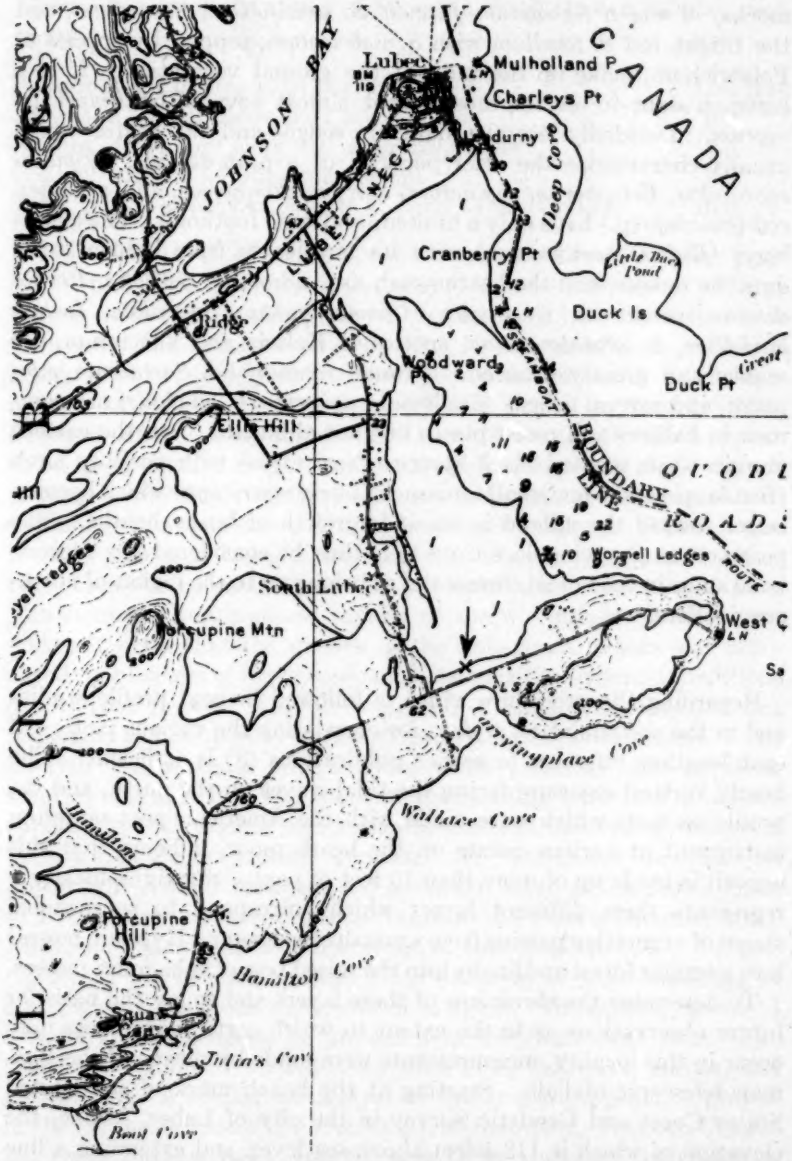

Fig. 1—Map showing location of South Lubec "heath" in Maine. The control data in relation to sea level were determined at the point marked by an arrow. The numbers in the shoal tidal flat indicate depths at mean low water.

mocks, of which *Sphagnum fuscum*, *S. acutifolium*, *S. medium*, and the bright red *S. tenellum* with *S. imbricatum*, topped by species of Polytrichum, make up the bulk of the ground vegetation. It is a common sight to see the moss carpet almost covered by *Empetrum nigrum*. Decidedly less abundant are sedges and the heaths which usually characterize the drier portions of a peat deposit. *Rynchospora alba*, *Eriophorum vaginatum*, *Scirpus caespitosus*, and a golden rod (*Solidago* sp.) have only a limited, scattered foothold. The cloudberry (*Rubus chamaemorus*) with its few leaves from hidden stems dots the mosses, and the heaths such as *Andromeda polifolia*, *Rhododendron canadense*, *Cassandra* (*Chamaedaphne*) *calyculata*, *Ledum latifolium*, *L. groenlandicum*, species of Kalmia and Vaccinium, are scanty and greatly dwarfed. *Drosera rotundifolia*, *Sarracenia purpurea*, and several lichens (*Cladonia rangiferina*, *C. uncialis*) are common in hollows and moist places but not abundant. On the eastern margin occur stunted black spruce (*Picea nigra*) with possibly birch (*Betula* sp.) and a few small tamarack (*Larix americana*) which become larger toward the upland in an undergrowth of bushy heaths. The peat area at Carryingplace Cove may thus be considered as a successional stage in the boreal climax and as belonging to the region of northern conifers.

III

Regarding the procedure which is followed in peat profile studies and in the accumulation of data for correlating the various factors at each location, reference to earlier publications (8) is sufficient. The nearly vertical exposure facing the tidal waves on the north, and the profile sections which were made with the American peat-sampling instrument at various points on the heath moor, indicate that this deposit is made up of more than 10 feet of peat. Stratigraphically it represents three different layers which correspond to successional stages of vegetation passing from a marsh of sedges and Hypnum mosses into a conifer forest and finally into the raised bog of sphagnum mosses.

To determine the elevations of these layers and to lay the basis for future observations as to the extent to which earth movements may occur in this locality, measurements were made by means of the Beaman telescopic alidade. Starting at the bench mark of the United States Coast and Geodetic Survey in the city of Lubec, Maine, the elevation of which is 118.4 feet above sea level, and extending a line south about three miles to South Lubec, the elevations obtained at the point indicated on the accompanying map are as follows:

Mean sea level elevations of layers in South Lubec, Maine, peat profile:

Surface of sphagnum moss peat layer	13.0 feet
Surface of conifer forest peat layer	6.0 "
Surface of hypnum moss and sedge peat layer	4.5 "
Contact with underlying mineral soil	3.0 "
Total thickness of peat deposit at point of observation	10.0 "

The upper layer of sphagnum moss peat varies in thickness from 6 to 9 feet. The material contains a moderate quantity of stringy-fibrous tufts from cotton-grass (*Eriophorum* sp.) but is rather free from roots and other impurities. The layer is reddish to yellowish brown in color, spongy-fibrous, and poorly decomposed. It shows a number of thin alternating bands of dark brown to grayish black, largely decomposed organic debris. Some of the narrow bands appear to be finely divided organic material which collected in shallow pools of water (*Schlenken*). Other bands are more convex in form and consist mainly of woody debris derived from heaths; they are probably due to short periods of drought that caused a temporary dominance of low ericaceous shrubs and favored an advanced stage of decomposition. The comparatively uniform texture of the well-preserved moss peat makes it plain that the growth of the sphagnum mosses was influenced by blankets of fog or cool-moist and maritime climatic conditions during that period. The accumulation of moss peat was slow but prolonged and completely buried an underlying forest of conifers. The inferred peat-forming processes are those primarily due to water saturation which had the effect of maintaining reduction processes (6:372) in both organic and inorganic material, instead of oxidation upon which decomposition depends. An alternation between an upper light-colored younger, and a darker, more decomposed, lower and older layer of moss peat, as traced in the cross sections of many European highmoors, does not occur in this locality.

Toward the bottom appears a buried forest of trees consisting of stumps with numerous roots, shown in fig. 2. The layer is about 1½ feet thick and seems to be present over the entire peat area. The specimens examined were derived from pine, tamarack, spruce, and possibly fir. A similar basal layer of woody peat appears to prevail in the heaths at Veazie and Denbo (8), at Jonesport, Trescott, Columbia Falls, Pushaw Lake, and Hermon Center, and an abundance of roots and stumps has been reported also for the peat deposits of north-

eastern Canada. The recent account of Auer (1) describes layers of stumps at the bottom of cross sections in peat deposits which are being cut away and exposed by the action of the waves in the Gulf of St. Lawrence. As layers of woody peat are present also in peat areas farther inland, it is logical to assume an extensive development of forests, spreading over wide stretches of country under conditions of environment which no longer exist. The climate, and probably coastal marine currents of this period, must have been warmer. The whole region must have passed into a drier stage throughout, and climatic conditions must have set in that were in consequence more continental and southerly in character than it is now in Maine.

The layer of peat resting directly on the mineral soil below and forming the bottom of the whole deposit, consists of a compact, yellow-brown, felty-matted network of well preserved stems and leaves from Hypnum mosses (*Amblystegium* sp. and others) in which are embedded the rhizomes of sedges (*Carex* sp., *Cladium* sp.), black rootstocks of *Equisetum* sp., seeds of *Menyanthes*, the elytra of beetles, and other inclusions. Sedimentary organic debris, indicative of ancient lakes or ponds, is not present. The layer of basal peat is about 16 inches thick and in an advanced stage of decay only at the upper limit supporting the stumps of trees *in situ*. There is nowhere an indication for assuming that at one time the area constituted a part of a lake formed by the building of a barrier beach across a recess in the coastal shore line, or that it supported plants growing in brackish or salt water. It is very probable, therefore, that the layer began to form when the sea level had retreated sufficiently to expose the shore to glacial waters from the melting ice-sheet. Species of Hypnum mosses, such as *Amblystegium*, were more abundant at that early period than at present, and a variety of sedges with cattail and reeds, scattered freely throughout the ancient marsh, occupied the habitat. The evidence obtained by soundings from peat areas elsewhere in Maine and Canada points strongly to the fact that the land laid bare by the receding ice was occupied at first by extensive sedge and reed marshes which spread over the more open, level, and wet places where forests could not gain a foothold. The northward migration of these plant communities must have occurred at the waning stage and during the steady recession of the ice border when climatic conditions began to be warmer and were better suited than now to the growth of these plants.

Thus it will be seen that since the glacial period many evidences

and important records of unusual interest have been left in peat profiles. The layers reveal the history of the region and point to the existence of a distinct regional succession in vegetation. They suggest that the coast must have projected at that time far enough above sea level to enable many species of plants, referred to by Fernald (15) as characteristic of southern coastal regions, to have migrated into northern localities. The majority of the plant remains in the three-layered pro-

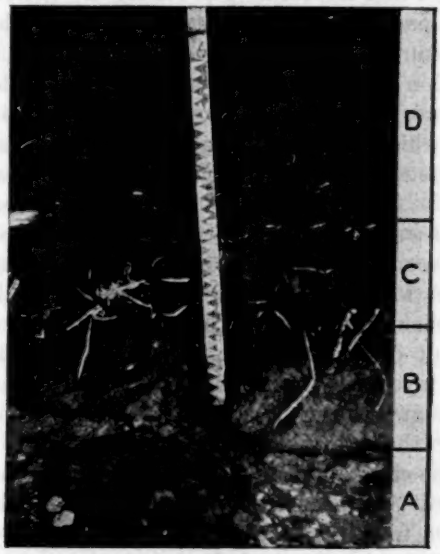

Fig. 2—Lower portion of the peat profile exposed by the action of tidal waves eroding the South Lubec "heath." In the illustration are shown (a) the contact of the underlying mineral soil with (b) the basal layer of peat derived from an ancient marsh of hypnum mosses and sedges, (c) the roots and stumps of a former conifer forest which spread over the country and (d) the superimposed layer of sphagnum moss peat. Photographed at low tide September 29, 1929 by R. J. Belton.

file of the South Lubec heathmoor are generically the same as those in the highmoors of Europe, of which the belt in Maine appears to be the western extension. Striking changes are recorded by the layers of peat, obviously indicating corresponding changes in climatic factors which condition the growth of plants and hence the regional characteristics and the distribution of broad groups of peatland.[2]

[2] For the general correlations between plant successions, stratigraphic features of peat profiles, and past climates, as recorded in moors, see "Reports of the conferences on cycles" Carnegie Institution of Washington, pp. 54–66. 1929.

The underlying mineral soil is a glacial gray bowlder clay, locally sandy to gravelly and stony where the material has been subjected to the action of marine currents and waves, as in the very shoal bay north of the peat area, showing a depth of one foot at mean low water.

Beneath the thick covering of peat the mineral soil is gray to bluish gray in color and resembles the "glei" horizon reported in descriptions of the moors of northern Europe. At the margin where the cover of peat is less thick and soil-forming processes are active owing to the influence of drainage and lower moisture conditions, the development of pedologic features may be observed. The mineral soil underlying the relatively thin peaty cover is characterized by a leached horizon which at the lower level is more or less sharply demarked by a brown horizon, below which a rust-colored, iron-stained and spotted horizon resembling "Ortstein" is recognizable. These features are especially well displayed in a peat area about 2½ miles northeast of Jonesport, Maine, which is being cut away by the waves of Chandler Bay, exposing natural sections. Marbut (19) has pointed out in his scheme for soil classification that profile characteristics of this type are the effects of podsolizing processes. There is no evidence of either a conspicuous amount of decomposition, leaching, or enrichment in the overlying peat layers, due primarily to the high moisture content of the material, its great absorptive power for atmospheric water and its coldness under the prevailing climatic conditions. Corresponding differences in the chemical composition between the three main layers may be expected. The surface layer of moss peat exhibits the peculiarities common to this type of peat-material, namely relatively low content of available nitrogen, and of mineral salts such as lime, a generally high acidity, and comparatively large quantities of poorly decomposed crude fiber (celluloses and lignin-like constituents) and ether-alcohol soluble substances. On the basis of these observations the belt of peatlands in northeastern coastal Maine, of which the South Lubec heath is the type locality, has been designated for convenience as "highmoors" of the oligotrophic group of peatlands, representing a telmato-ombrogenic, three-layered profile series (9).

IV

Comparisons in terms of economic uses show that none of the highmoors are under cultivation. They are practically a waste in the sense that they have no value for agricultural crops, for grazing of cattle and horses, or for afforestation under existing conditions. No

attempt is being made to utilize the moss peat commercially for the purposes to which the great quantities imported from Europe have long been employed. It is safe to state that at least 85 per cent of the "heaths" in the neighborhood of Jonesport, Maine, contain a quality of moss peat equal if not superior to the imported material. The supply merits attention as a basis of local industries, partly because the location of some of the highmoors is unusually favorable for handling and shipment by vessels from adjacent harbors. The areas would furnish a large supply of moss peat for use as an absorbent in stables, bedding for poultry, mulch for certain evergreen shrubs and trees, organic filler for highgrade, concentrated, mineral fertilizers, and as packing material for storing bulbs, fruits and vegetables. A number of profitable uses of different kinds of peat have been enumerated in an earlier publication (6) and in Bulletin 802, issued by the U. S. Department of Agriculture. The present uses for which peat moss is especially adapted include composts as an organic manure, an ingredient of top dressing on golf courses and in greenhouses, and in the general improvement of soil texture. The different methods employed for excavating and handling peat and for preparing composts have been described in Circular 252 of the U. S. Department of Agriculture.

SUMMARY

1. To understand the nature of the dome-shaped "heaths" on the northeastern coast of Maine consideration is given to the structural features of vertical cross-sections in the existing environment, and to the history of the region after the retreat of the ice sheet.

2 The intrinsic characteristics of the South Lubec peat profile are due mainly to three major successions of vegetation, closely correlated, it seems, with differences in climatic conditons; the profile represents three distinct layers of peat, superimposed upon one another and derived from marsh, forest, and sphagnum moss plant communities.

3. The arctic alpine plants, such as *Empetrum nigrum* and others found in the present surface vegetation are not an early but a late stage of succession.

4. Evidence appears to point conclusively to a former extension of the South Lubec "heath" moor from its present termination at Carryingplace Cove as far probably as Woodward Point. Such a land connection affords the only possible explanation of the age, thickness, stratigraphy and other profile features which the peat area has in common with other coastal and inland highmoors, notably with the highmoors at Jonesport and Columbia Falls, Maine.

5. At one time probably a marine beach of sand and gravel projected for a long distance in a northwest direction across the shoal tidal flat, connecting the north shore of West Quoddy Head with the mainland. Shifting marine currents have doubtless caused the removal of a barrier beach and exposure of the highmoor to the cutting action of the waves. The sea has operated on the coast in this region since comparatively recent times.

6. The position of the South Lubec peat area in relation to sea level supports the conclusion, reached by investigators in other sciences, of a recent and progressively greater submergence of the coast toward the northeast.

7. It is probable that considerable areas of coastal plain existed in geologically recent times, possibly from New Jersey to Newfoundland, which have been worn away by a shift in marine currents and that a northward migration of plants took place when forests gained a foothold upon sedge marshes or lowmoors, and spread extensively under climatic conditions that were warmer than it is now in Maine.

8. The South Lubec "heath" is a member of the "highmoors" of the oligotrophic group of peatlands, and is characterized by a three-layered, telmato-ombrogenic profile series. The development of pedologic features at the margin of the heath indicates the effects of podsolizing processes active in this region.

9. The economic uses of the highmoors in Maine merit greater attention. The moss peat in the South Lubec "heath" and in the areas of peat around Jonesport, Maine, is equal if not superior to the imported material. Its use as a commercial product for various purposes can be made profitable in localities with facility for shipment by vessels.

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BOTANY.—*A new species of* Esenbeckia *from Texas.*[1]

C. V. MORTON, U. S. National Museum. (Communicated by WILLIAM R. MAXON.)

On April 15, 1929, Mr. Harvey Stiles noticed several trees on the banks of the Resaca Vieja in Cameron County, Texas, which he did not recognize. From one of these he made an herbarium specimen which he gave to Mr. Robert Runyon, of Brownsville, Texas, who subsequently sent it to the United States National Museum for identification. On examination it proved to belong to the genus *Esenbeckia* (Rutaceae-Pilocarpinae), a genus hitherto not known to be indigenous to the United States. Moreover, it is obviously distinct from any of the six or seven species of the genus known from Mexico and the West Indies.

Mr. Runyon, who has since made several visits to the locality, supplies the following note: "There are four small, round-topped trees of the *Esenbeckia* on the banks of the Resaca Vieja, three miles north-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received February 15, 1930.

west of Los Fresnos. The leaves put out very late in the spring. In the last part of June they were about one-third grown, and on the second of July the flowers were fairly well open. The trees flower and fruit twice annually. The fruit bursts open and scatters the seeds at maturity."

Esenbeckia runyoni Morton, sp. nov.

A small round-topped tree nearly 5 meters high; twigs glabrous up to the inflorescence; leaves digitately compound, 3-foliolate; petioles 1–4 cm. long, pubescent; leaflets elliptic, rounded at base, short-petiolulate (2–5 mm.), obtuse at apex, 6–10 cm. long, green and glabrous on both sides, densely pellucid-punctate, entire, the margin thickened; inflorescence paniculate, dense, not exceeding 8 cm. in length, the branches of the panicle alternate, puberulent, the bracts subulate; pedicels 2–3 mm. long, each with a small subulate bract at the middle, pubescent; flowers cream colored, about 8 mm. broad; sepals deltoid, roundish at apex, pubescent, ciliolate, 1 mm. long, scarcely imbricate; petals oval, 3–3.5 mm. long, glabrous, glandular on the back; stamens 5, alternate with the petals; filaments shorter than the petals, about 2 mm. long. glabrous; anthers oval, 1 mm. long; ovary 5-lobed, the fleshy disk 2.5 mm. broad; style basal, short and fleshy, 1–1.5 mm. long, glabrous; stigma terminal, capitate; fruit a woody 3, 4, or 5-celled capsule, roughened on the exterior but without conspicuous tubercles; horny endocarp conspicuous, at maturity splitting elastically and ejecting the seeds, the capsule after splitting about 2 cm. long and 3–4 cm. wide; seeds dark brown, about 10 mm. long and 8 mm. wide, with a short curved beak.

Type in the U. S. National Herbarium, no. 1,438,940, collected on the bank of the Resaca Vieja, 3 miles northwest of Los Fresnos, Texas, July 8, 1929, by Robert Runyon (no. 177), a flowering specimen. Fruiting material collected from the same group of trees by Harvey Stiles, April 15, 1929, is mounted on sheet no. 1,436,973.

Esenbeckia runyoni belongs to the section *Hymenopetalae* Engl. and is most closely related to *E. pentaphylla* (Macfad.) Griseb., of Jamaica and southern Mexico, from which it is distinguished by its 3-foliolate (never 5-foliolate) leaves and its smaller leaflets, and by other more important diagnostic characters, as shown in the following key. The key also distinguishes *E. runyoni* from its nearest geographical relative, *E. berlandieri* of northern Mexico. The other species of the genus which occur in Mexico (*E. hartmannii*, *E. flava*, *E. nesiotica*, *E. macrantha*, and *E. collina*) are not closely related.

KEY

Sepals scarcely imbricate, deltoid, pubescent; bracts of the inflorescence subulate. Disk 2.5 mm. broad; seeds with a curved beak... **E. runyoni.**

Sepals strongly imbricate, much broader than long, and broadly rounded at apex; bracts of the inflorescence short, triangular-ovate.

Disk 2.5 mm. broad or more; inflorescence elongate; sepals pubescent; seeds with a curved beak..... **E. pentaphylla.**

Disk 1.5 mm. broad or less; inflorescence more compact; sepals glabrous or sometimes ciliolate; seeds with a straight beak..... **E. berlandieri.**

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

998TH MEETING

The 998th meeting, constituting the 59th annual meeting, was held in the Cosmos Club Auditorium, December 7, 1929, at 8:15 P.M.

The Treasurer reported expenditures of $1182.92 for the year, and stated that the active membership of the Society is 227.

The Secretaries reported that the following new members were elected during the year: R. R. BODLE, F. C. BRECKENRIDGE, E. J. BROWN, G. S. COOK, M. J. EVANS, R. E. GOULD, W. D. HERSHBERGER, C. S. HOWARD, C. J. KSANDA, H. E. MCCOMB, H. B. MARIS, R. F. MEHL, J. H. TAYLOR, B. L. WILSON.

The following deaths were reported: S. J. MAUCHLY, C. V. HODGSON, E. L. JONES, A. C. TRUE, H. C. FRANKENFIELD, FRANCIS A. TONDORF, J. P. AULT.

The following officers were declared elected for the year 1930: *President*, W. D. LAMBERT; *Vice presidents*, F. E. WRIGHT; *Corresponding Secretary* H. L. CURTIS; *Corresponding Secretary*, L. V. JUDSON; *Treasurer*, N. H. HECK; *Members-at-large of the General Committee*, E. W. WOOLARD, O. H. GISH.

At the conclusion of the business meeting PAUL SOLLENBEIGER gave an illustrated address to the Society (by invitation) on *The Naval Observatory eclipse expedition to Iloilo, P. I.*

999TH MEETING

The 999th meeting was held in the Cosmos Club Auditorium, January 4, 1930.

The address of the evening was given by the retiring President, Dr. LEASON H. ADAMS, on *The significance of pressure in geophysical investigations.*

1000TH MEETING

The 1000th meeting was held in the Cosmos Club Auditorium, January 18, 1930.

The first communication in the celebration of the 1000th meeting was an illustrated address by W. J. HUMPHREYS on *The Philosophical Society of Washington through a thousand meetings.* After a résumé of the history of the Society a number of the distinguished past presidents of the Society were shown upon the screen.

Reminiscences of the early days of the Philosophical Society were given by J. H. GORE and by C. F. MARVIN.

1001ST MEETING

The 1001st meeting was held in the Cosmos Club Auditorium, February 1, 1930.

Program: H. L. DRYDEN and A. M. KUETHE, *Effect of turbulence in wind tunnel experiments.* A brief historical summary was given of the appearance of certain discrepancies in measurements of the air resistance of spheres and airship models in different wind tunnels. On the basis of qualitative experiments the discrepancies have in the past been attributed to turbulence, i.e.

the small ripples or eddies superposed on the approximately steady air-stream. The Bureau of Standards in coöperation with the National Advisory Committee for Aeronautics has developed a method of measuring turbulence quantitatively and has given definite experimental proof that the discrepancies are to be attributed to an effect of turbulence. Further, it is possible to explain the effects as due to an effect of turbulence on the critical Reynolds Number of the boundary layer at which the flow changes from the laminar to the eddying type. (*Author's Abstract.*)

W. F. WALLIS, *A comparison of magnetic disturbance at different stations.* This paper states briefly some of the results of a discussion of the magnetic records obtained during the MacMillan Baffin Land Expedition of 1921–22, as compared with the results from several other observatories distributed over the Earth. As a suitable basis for comparison a short, well-defined, world-wide, magnetic storm (March 14, 1922) was selected, and departures from normal values were compiled and compared by three methods. The first method is based on the vector ΔR which is the difference between the disturbed and normal total-intensity vectors, F and F_o, referred to three rectangular coördinates. The second method involves the excess energy of the magnetic field due to the disturbance. The third method is based on a formula for magnetic activity proposed by Chree, namely, $C(R_1^2 + R_2^2 + R_3^2)$, where C is any convenient constant and R_1, R_2, and R_3 are absolute daily ranges in three rectangular components of the total magnetic intensity. Any one of these methods gives results which may be taken as measures of magnetic disturbance. The disturbance values, computed by the three methods, when plotted according to magnetic latitude, give three curves closely resembling each other, and resembling also the curve of auroral frequency in its relation to magnetic latitude. The conclusion is that the geographic distribution of magnetic activity during disturbance bears a close relation to the auroral zone, and there is evidence that the zone of maximum auroral frequency is also a zone of maximum magnetic activity. A diagram, giving hourly mean horizontal and vertical-intensity disturbance vectors during the 18 hours of the magnetic storm of March 14, 1922, shows that, during the progress of the storm, these vectors vary widely in both direction and amount. If, however, instead of dealing with a single disturbance, we take average values of the disturbance vectors over several months, including many disturbances both large and small, there is a marked regularity in the directions of these vectors for the individual stations, and for all stations the general direction of the horizontal-intensity disturbance vectors is southward. This indicates that the disturbing currents in the upper atmosphere flow in general from east to west around the Earth. (*Author's Abstract.*)

J. E. WILLIS, *Recent experiments with timekeepers.* An account was given of experiments with several electrical methods of impulsing clock pendulums, including a method utilizing the amplified current of a photoelectric cell, the illumination of which is controlled by the motion of the pendulum, to charge a condenser after passing through the impulse coil which reacts on a permanent magnet to give energy to the pendulum. Pendulums were driven at amplitudes less than a tenth and approaching a hundredth the customary amplitudes of clock pendulums, so that the circular error was theoretically of the order of one part in ten million. Such small amplitudes are not practical for mechanically driven pendulums. Since driving impulses of equal intensity occurred on each half-stroke of the pendulum and at the same point in space (neglecting lag of impulses), the epoch changes due to non-centering of impulses were balanced. The epoch changes due to lag of impulses were con-

sidered to be reduced to the order of one part in a million, and the variables concerned were measured. Observations with free pendulums indicated that the damping coefficient is less for small amplitudes than for large amplitudes. The observed timekeeping of the clocks of small amplitudes seemed to indicate that disturbances such as microseisms, by which such clocks are obviously more affected than are ordinary clocks, may be the limiting cause of inaccuracy in clocks with a single pendulum. Preliminary experiments with a pair of pendulums so connected that they keep a half cycle apart suggest the feasibility of the use of such a system in earthquake-proof clocks, which may have a higher order of accuracy than the clocks now in use. (*Author's Abstract.*)

OSCAR S. ADAMS, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

On February 25th the American Geographical Society awarded the Daly gold medal to Dr. N. H. DARTON for extensive explorations in the western United States and Mexico, and the Cullum gold medal to Dr. C. F. MARBUT for his work on the distribution of soils in the United States, South America, and Africa.

Miss FREDERICA DE LAGUNA, a graduate student in Anthropology at Columbia University, who accompanied a Danish archeological expedition to Greenland last summer, recently spent a week in the Division of Ethnology of the U. S. National Museum, studying the Alaskan material excavated by Mr. COLLINS.

Mr. H. J. REINHARD, of the Texas Experiment Station, is spending several weeks at the National Museum, working on a group of muscoid flies.

Mr. ALBERT C. SMITH, of the New York Botanical Garden, spent the month of January at the Division of Plants of the National Museum, assisting Mr. KILLIP in sorting the material they recently collected in Peru and Brazil. The work of mounting the National Museum's set of 9200 collection numbers has been started, and the duplicate sets will soon be ready for distribution.

The Council of the Fifteenth International Geological Congress, meeting in South Africa in 1929, accepted an invitation from the geologists of the United States to hold the Sixteenth Congress in this country. An organization committee has been formed, as required by the rules adopted by the Thirteenth Congress, held in Brussels in 1922, and plans are being made for the entertainment of the Congress. Nineteen hundred thirty-two has been agreed upon as the year in which the meeting will be held, and the principal sessions will probably be in Washington, with excursions to points of geologic interest in the United States. The petroleum resources of the world has been agreed upon as a major topic for discussion.

LYMAN F. KEBLER, for many years government specialist in drugs and medicines, dealing with the enforcement of food, drug, and mail order laws, has been made medical director of the Tennessee Products Corp., Nashville, Tenn., where his work will include assistance in the utilization of by-products, medicinally and otherwise, as well as many health matters connected with the corporation's activities. Doctor Kebler will take over his new duties April 1.

Doctor Kebler will continue to be medical director of the John McEntee Bowman health interests, identified with the Biltmore chain of hotels, and in addition to his general headquarters in Washington, D. C., will have offices in Nashville, Tenn., and New York City.

The Charles Lathrop Pack Forest Education Board, founded by the Charles Lathrop Pack Forestry Trust of Washington, D. C. announces a number of fellowships in forestry for the year 1930–31. The purpose of the fellowships is to encourage men who have shown unusual intellectual and personal qualities to obtain training that will best equip them for future leadership either in the general practice of forestry, in the forest industries, in the teaching of forestry, in forest research, or in the development of public forest policy.

The awards will be made to gifted men who demonstrate natural powers of intellectual and personal leadership, and who intend to make forestry their life work. The sum of $10,000 is available the first year. The awards will range from $500. to $2500. or more in exceptional cases and will ordinarily be restricted to men of American or Canadian citizenship. No restrictions are made as to age, educational status or practical experience, but great emphasis will be placed on character, intellect, qualities of leadership, and similar qualifications.

The administration of these fellowships has been placed in the hands of the Charles Lathrop Pack Forest Education Board, which is composed of the following: *Chairman*, HENRY S. GRAVES, Dean, School of Forestry, Yale University, New Haven, Conn.; *Secretary*, WARD SHEPARD, United States Forest Service, Washington, D. C.; SAMUEL T. DANA, Dean, School of Forestry and Conservation, University of Michigan, Ann Arbor; JOHN FOLEY, Purchasing Agent, Pennsylvania Railroad, Philadelphia; ARTHUR NEWTON PACK, Princeton, N. J., Director, Charles Lathrop Pack Forestry Trust; E. O. SIECK, Director, Texas Forest Service, College Station, Texas; ELLWOOD WILSON, Chief Forester, Laurentide Division, Canada Power and Paper Corporation, Grande Mere, Quebec; HUGO WINKENWERDER, Dean, College of Forestry, University of Washington, Seattle; RAPHAEL ZON, Director, Lake States Forest Experiment Station, St. Paul, Minn.

Application forms and other information can be obtained from the Secretary of the Charles Lathrop Pack Forest Education Board, 1214 Sixteenth Street, N. W., Washington, D. C. For the current year the completed applications must be in the hands of the Secretary not later than April 15.